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(54) Abstract Title
Pressurised system for protecting signal transfer capability

(57) To prevent damage to signal transmission lines 30, such as electric cable or optical fibres, they are incased by flexible, rigid, or semi-rigid tubing 34, that extends from the surface down to a connector 38 and a tool 26, such as a packer, flow metre or control valve. The tube 34 and connector 38 are filled with fluid 40 such as high density, hydraulic, or dielectric liquid, and a pump 42 maintains the fluid pressure so that it is greater than the external pressure, so preventing inward flow of wellbore fluids, even if a leak occurs, and this can also be used for hydraulic control of tools. The signal line 30 may be surrounded by insulation (fig. 4, 48), have a physical support (fig. 6b, 57), be connected to a float (fig. 6b, 54), or have a plurality of wings (fig. 6b, 59). A penetrator (fig. 8, 74) is provided for isolating zones (fig. 8, 76, 78), with a check-valve (fig. 8, 88) that prevents back-flow, whilst allowing the signal line 30 to pass through. The connector 38 has a tool connection portion (fig. 7, 60), and a connection chamber (fig. 7, 64) and allows the signal line 30 to pass through.

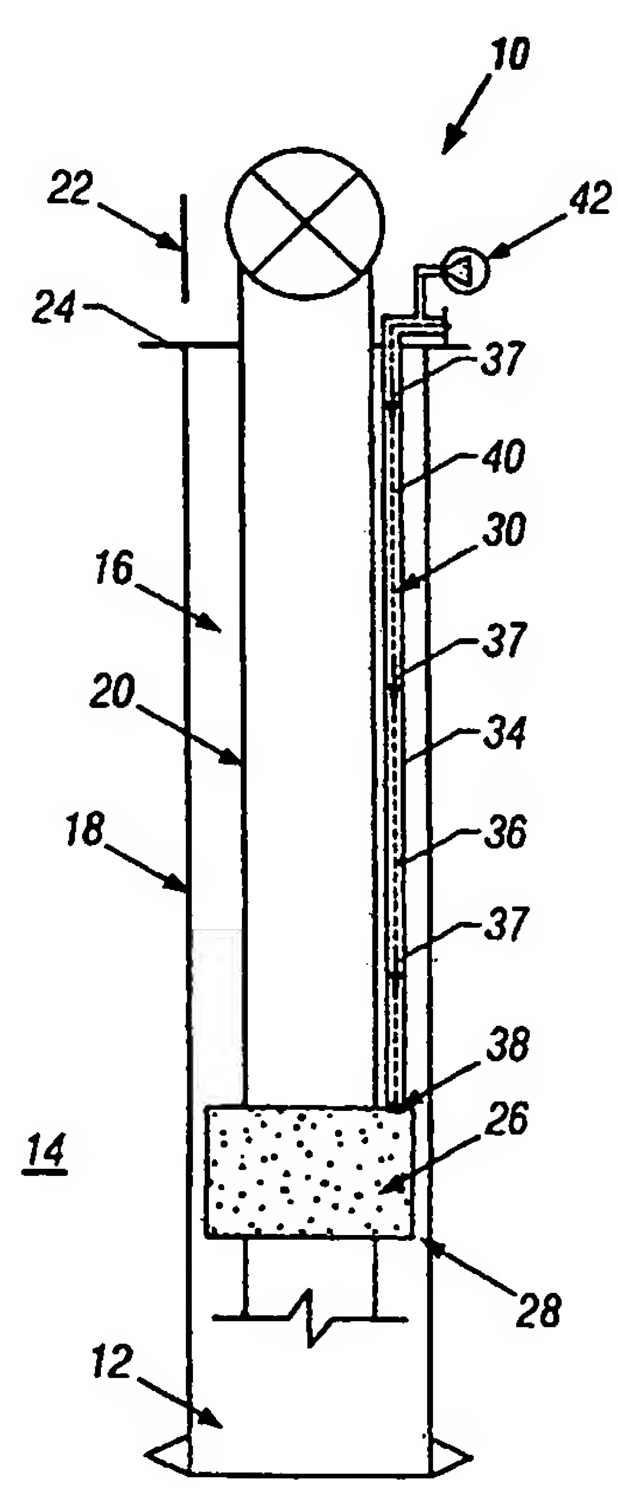

FIG. 2

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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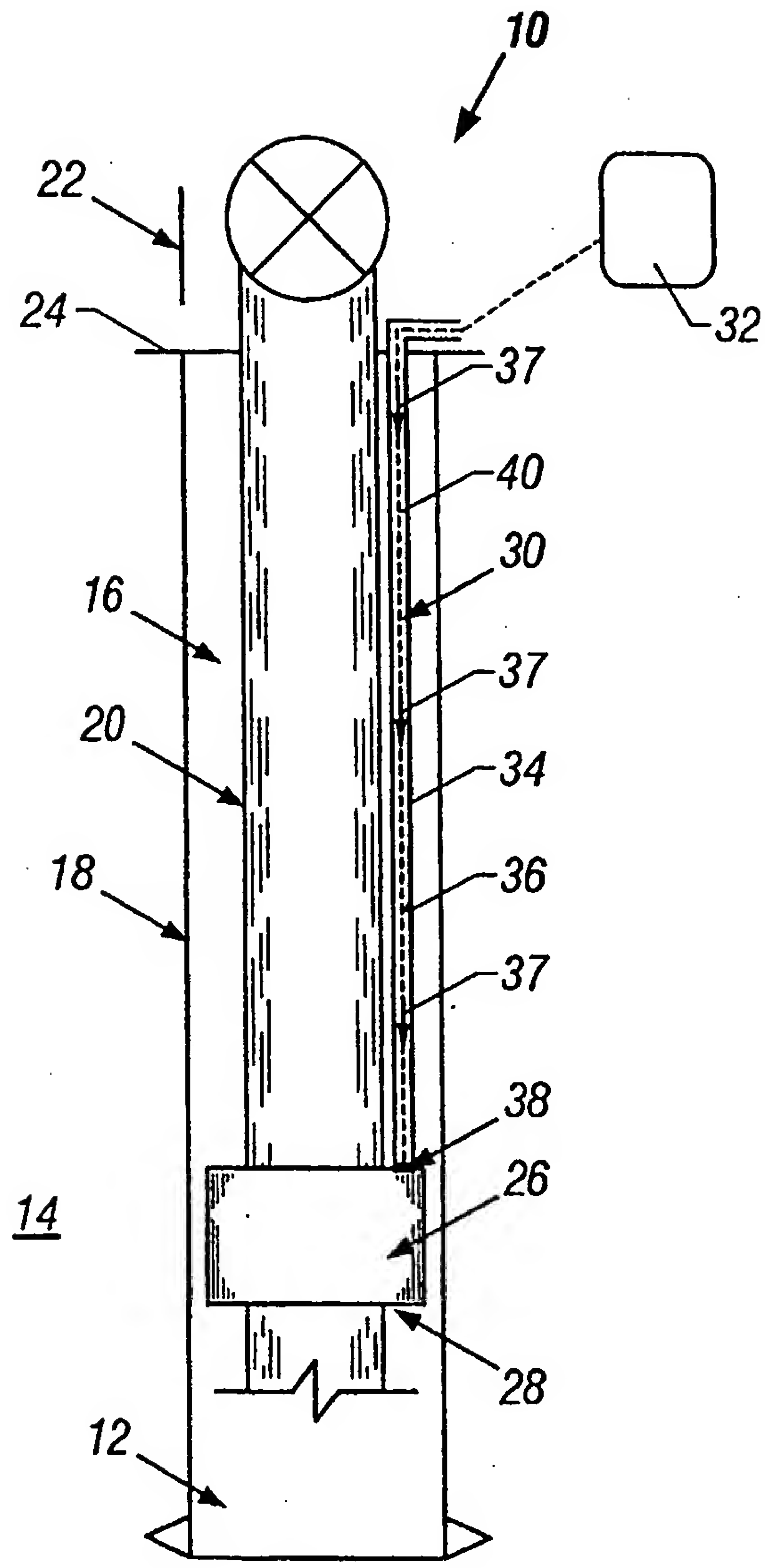


FIG. 1

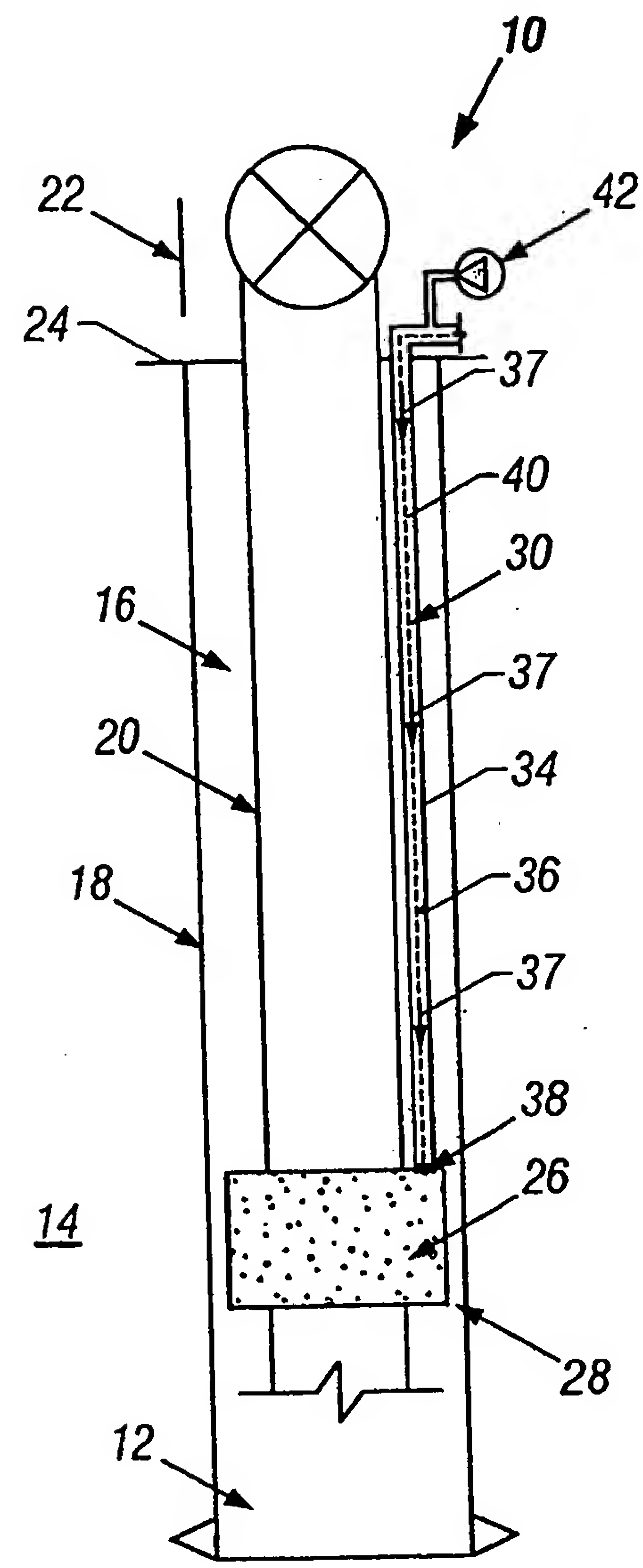


FIG. 2

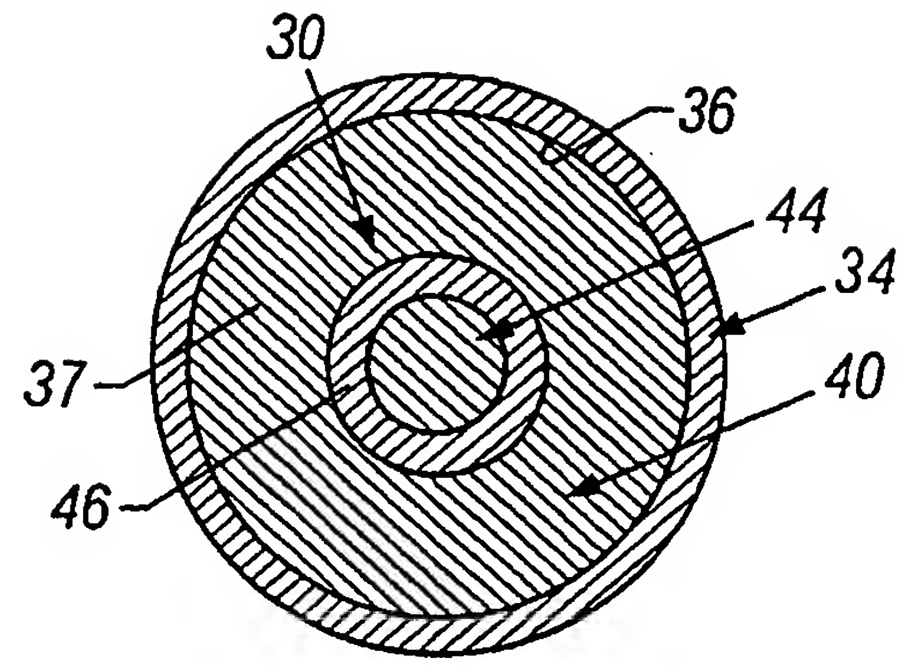


FIG. 3

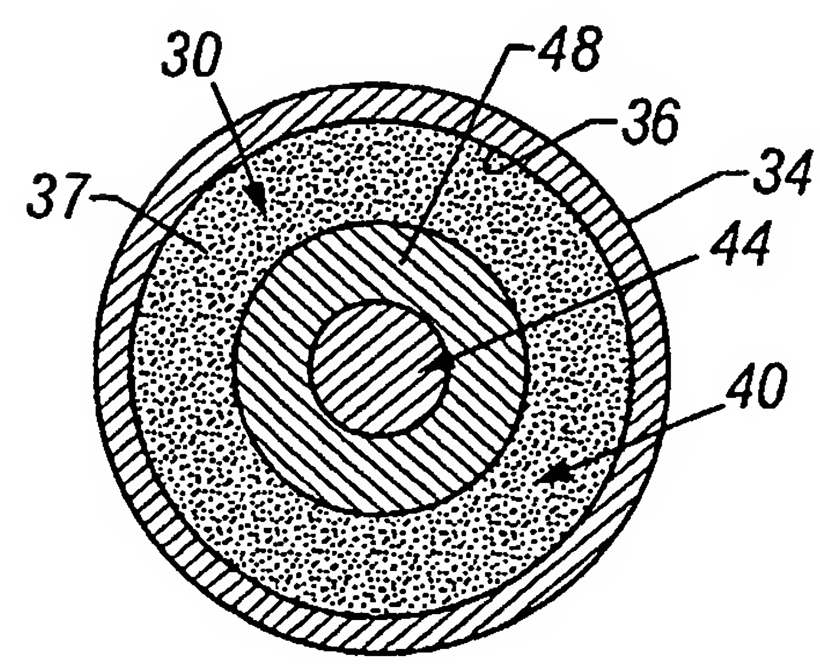


FIG. 4

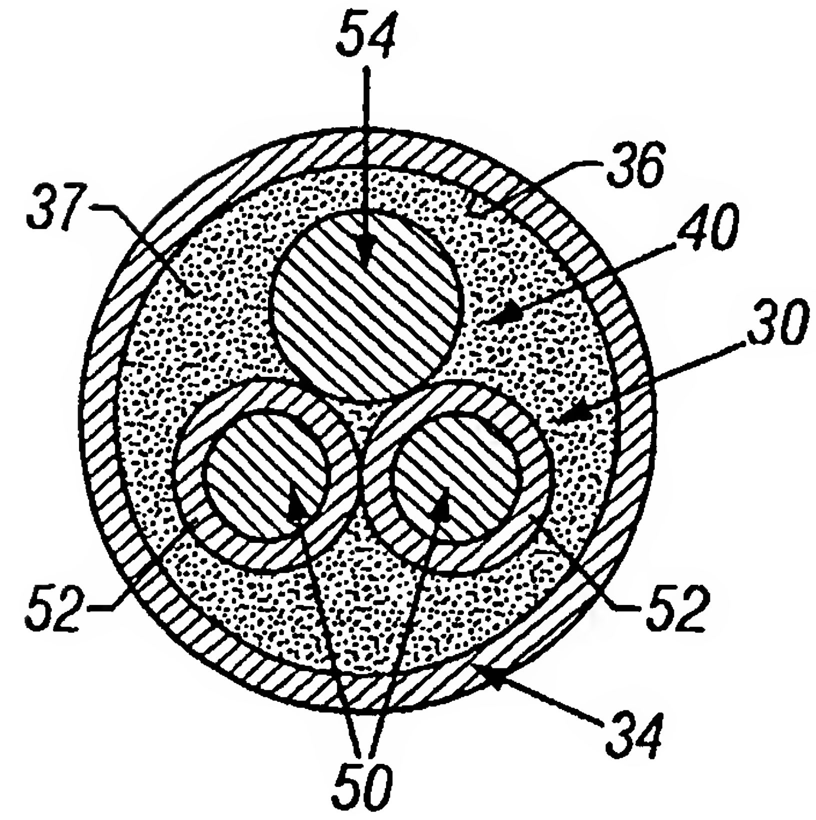


FIG. 5

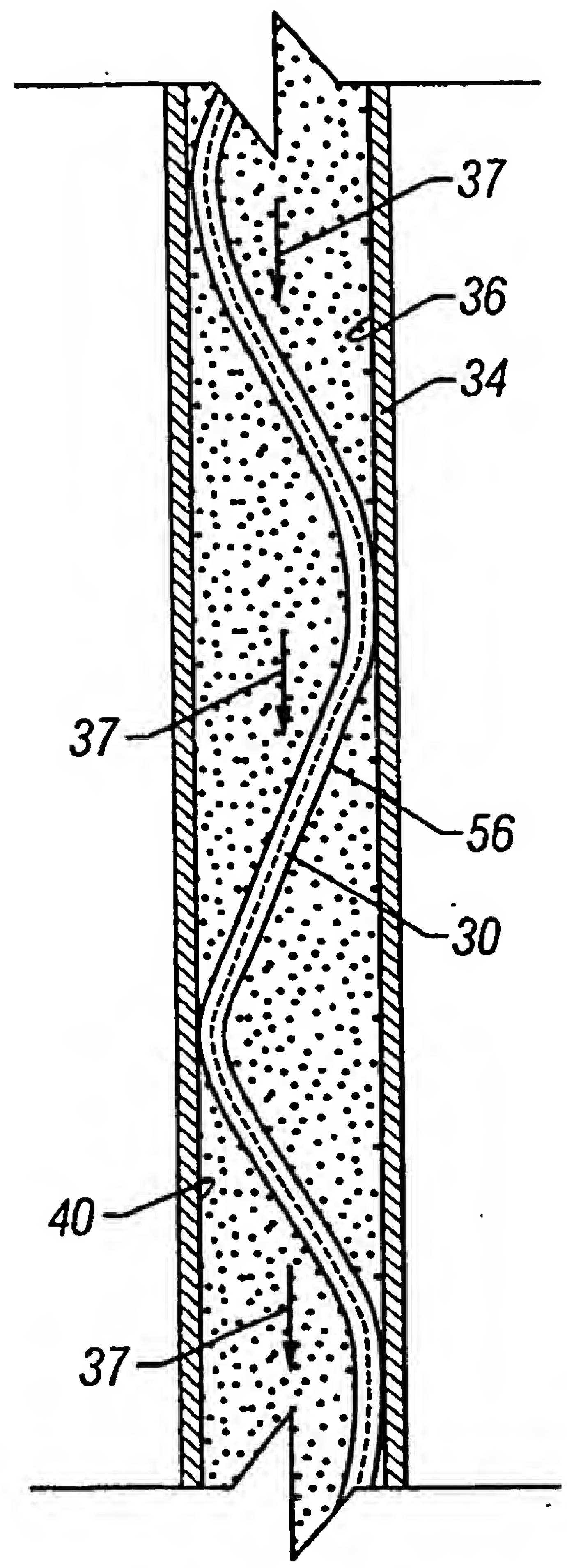
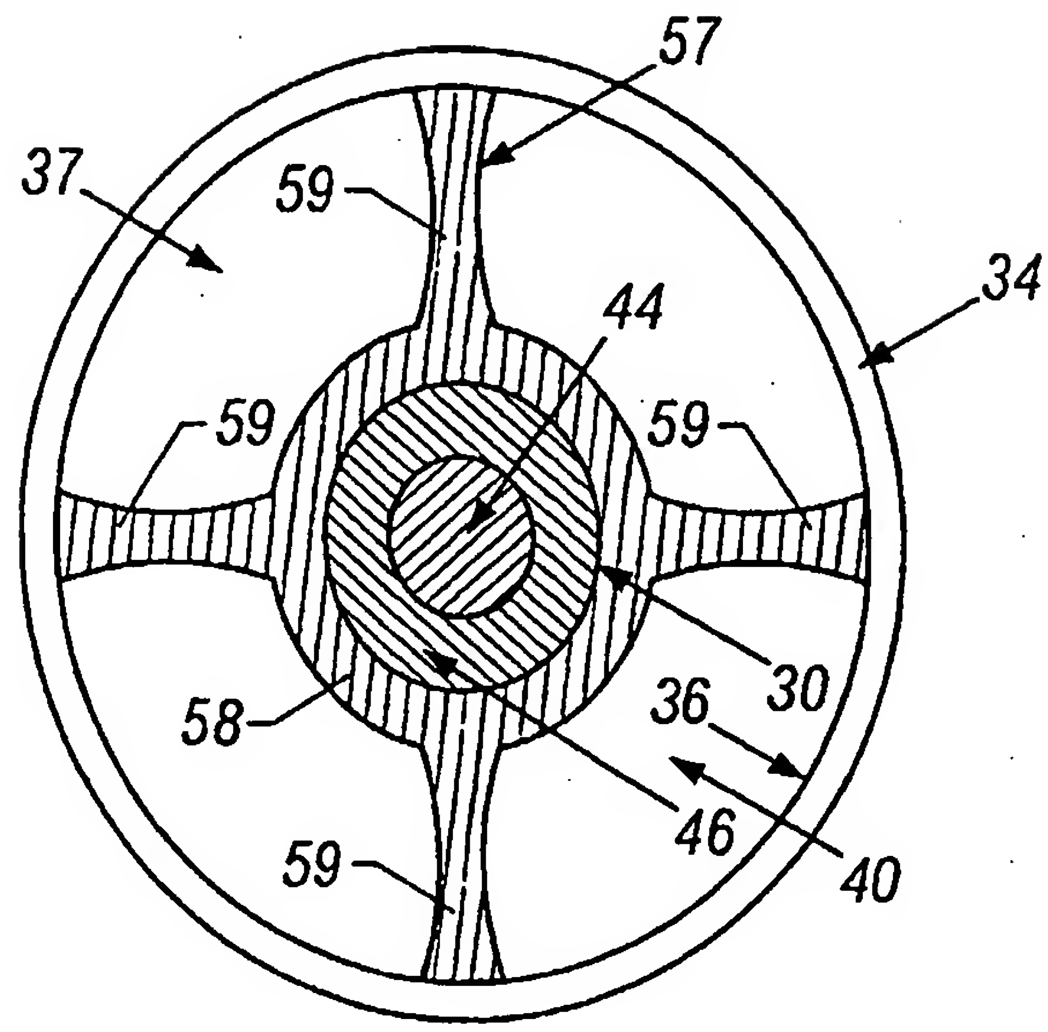


FIG. 6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34
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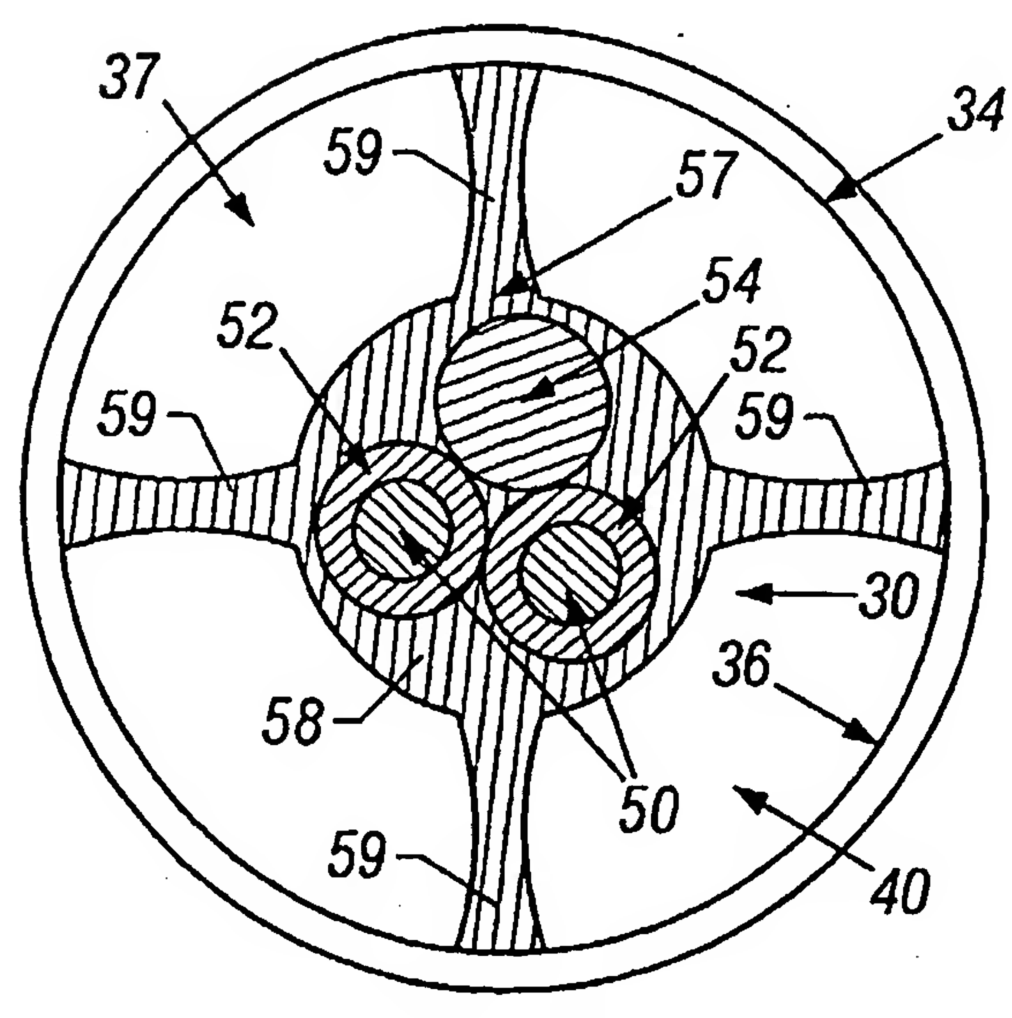
40

FIG. 6A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59
40

FIG. 6B

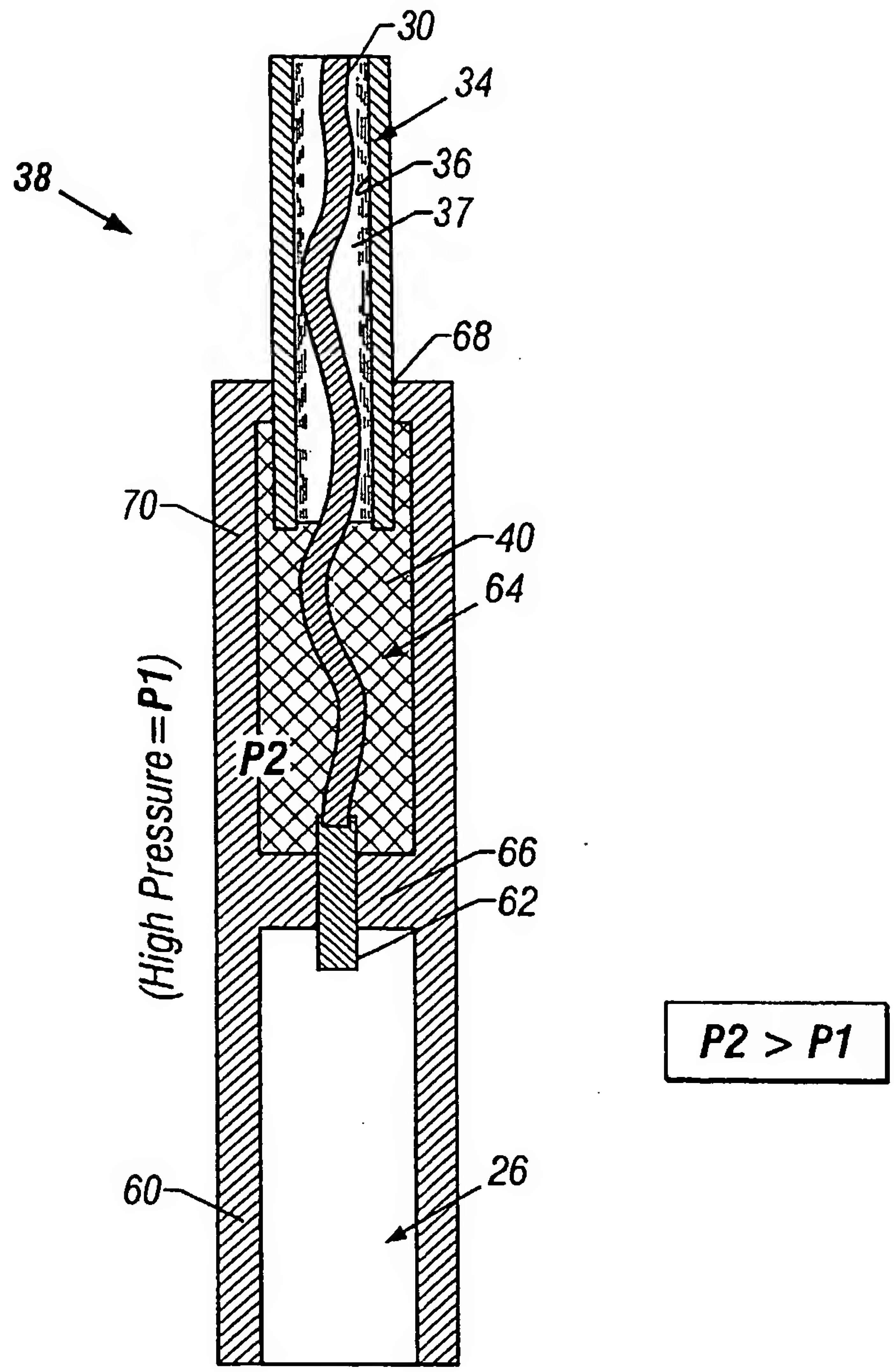

FIG. 7

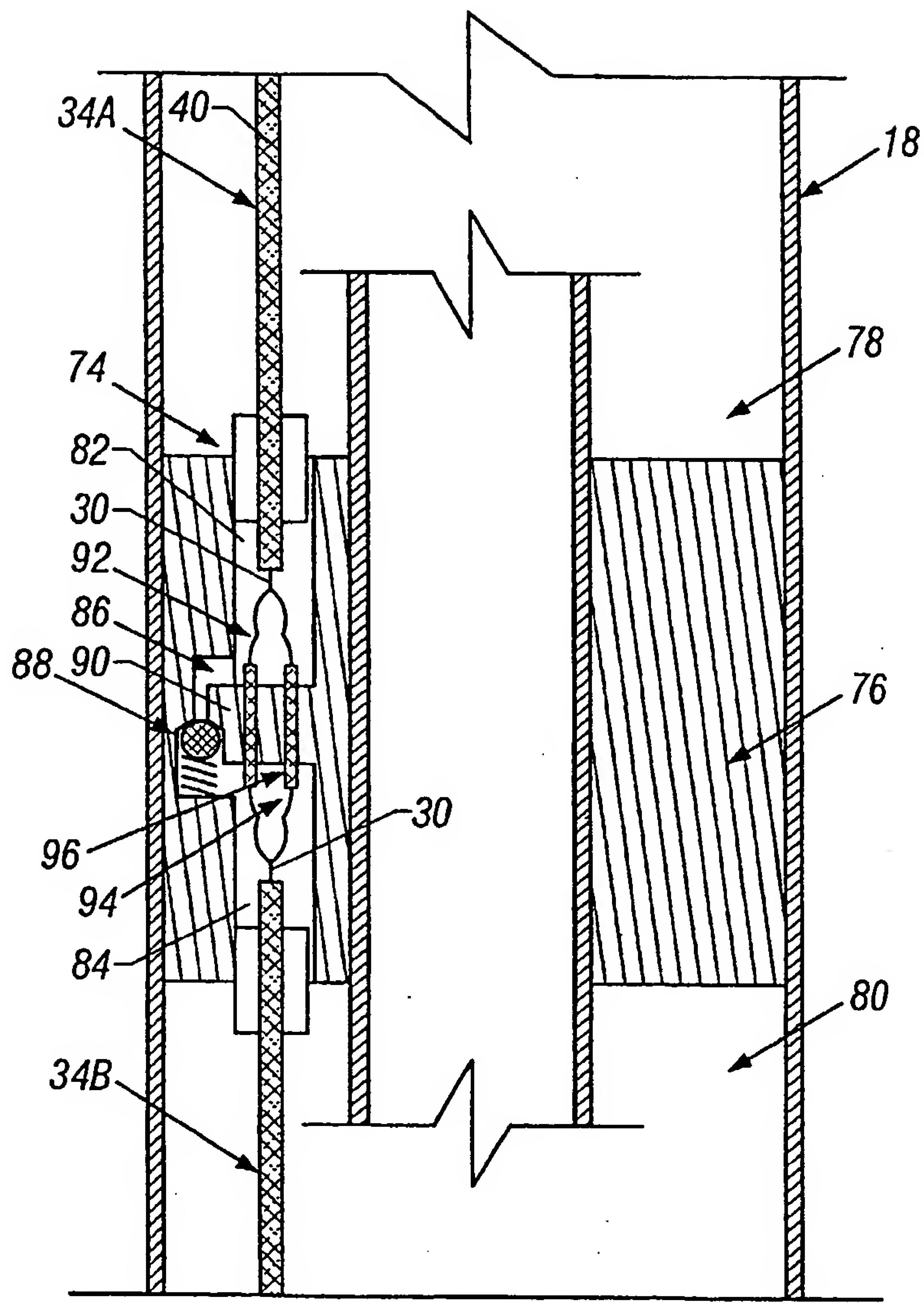

FIG. 8

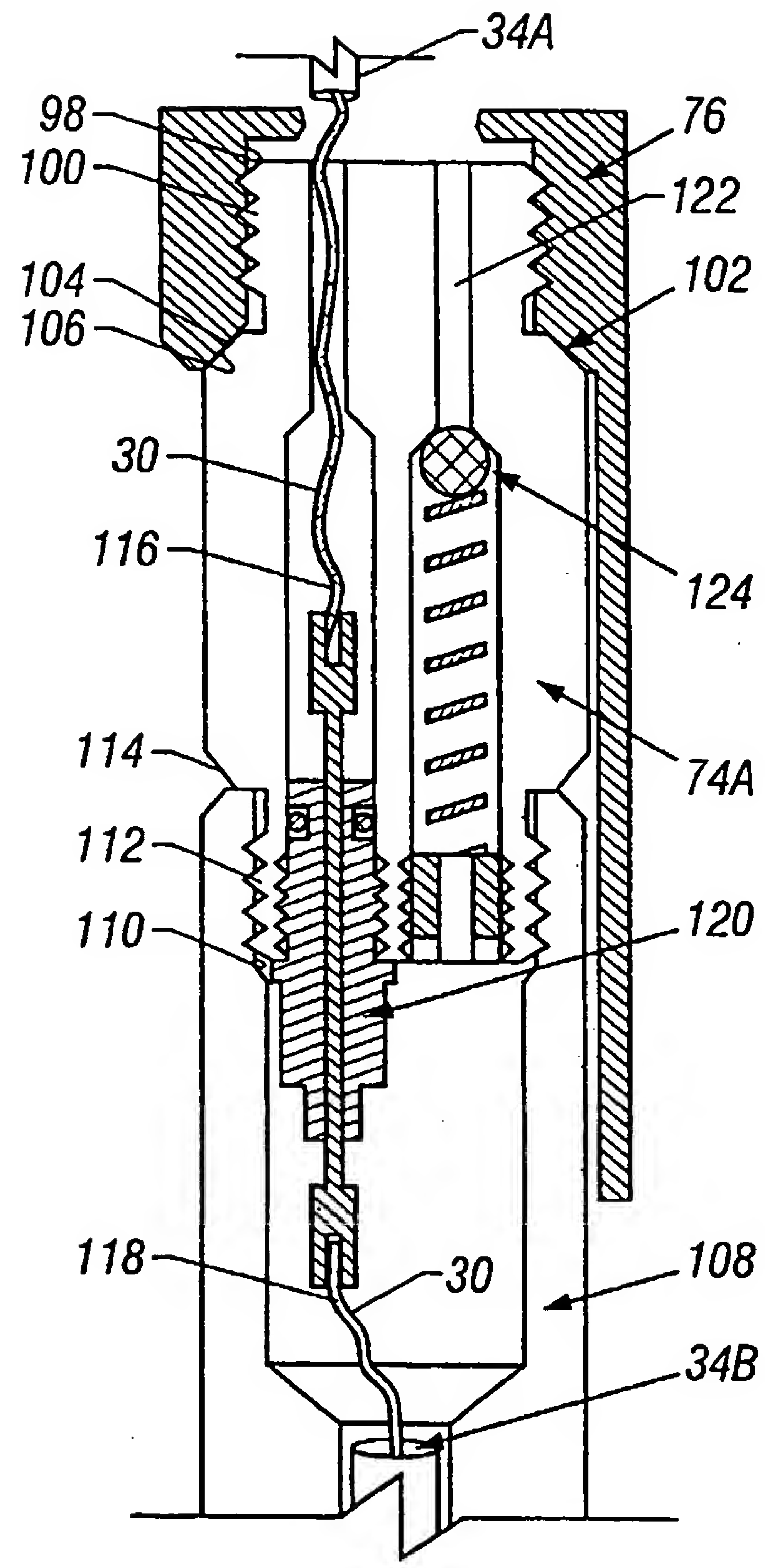
34A
98
100
104
106
76
122
102
30
116
124
74A
114
112
110
120
118
30
108
34B

FIG. 9

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PRESSURIZED SYSTEM FOR PROTECTING SIGNAL TRANSFER CAPABILITY AT A SUBSURFACE LOCATION

FIELD OF THE INVENTION

The present invention relates generally to a system for prolonging the life of a signal transfer line disposed at a subsurface location, and particularly to a system for protecting a signal transfer line, such as those containing electric cable and/or optic fiber, in a downhole, wellbore environment.

BACKGROUND OF THE INVENTION

A variety of tools are used at subsurface locations from which or to which a variety of output signals or control signals are sent. For example, many subterranean wells are equipped with tools or instruments that utilize electric and/or optical signals, e.g. pressure and temperature gauges, flow meters, flow control valves, and other tools. (In general, tools are any device or devices deployed downhole which utilize electric or optical signals.) Some tools, for example, may be controlled from the surface by an electric cable or optical fiber. Similarly, some of the devices are designed to output a signal that is transmitted to the surface via the electric cable or optical fiber.

The signal transmission line, e.g. electric cable or optical fiber, is encased in a tube, such as a one quarter inch stainless steel tube. The connection between the signal transmission line and the tool is accomplished in an atmospheric chamber via a connector. Typically, a metal seal is used to prevent the flow of wellbore fluid into the tube at the connector. This seal is obtained by compressing, for example, a stainless steel ferrule over the tube to form a conventional metal seal.

However, the hostile conditions of the wellbore environment render the connection prone to leakage. Because the inside of the connector and tube may stay at atmospheric pressure while the outside pressure can reach 15,000 PSI at high temperature, any leak results in the flow of wellbore fluid into the tube. The inflow of fluid invades the internal connector chamber and interior of the tube, resulting in a failure due to short circuiting of the electric wires or poor light transmission through the optic fibers. This, of course, effectively terminates the usefulness of the downhole tool.

Additionally, the signal transfer lines often extend through the protective tube over substantial distances, e.g. to substantial depths. If not supported, the weight of the signal transfer lines creates substantial tension in the lines that can result in damaged wires/fibers. Even if the

signal transfer lines can withstand the tension, any cutting of the wires/fibers results in severe retraction of the lines into the tube. For example, when a technician cuts the lines to repair a damaged cable or to cross a tubing hanger, packer, annulus safety valve, another tool etc., the retraction occurs.

A common solution is to add a filler in the annulus between the interior surface of the tube and the wires and/or fibers. The filler may comprise a foam rubber designed to expand with temperature to fill the gap between the signal transfer lines and the interior surface of the tube. However, such a filler does not alleviate the problem of substantially reduced interior pressure relative to the exterior pressure that can result in the inflow of deleterious wellbore fluids.

SUMMARY OF THE INVENTION

The present invention provides a technique for preventing damage to signal transmission lines, such as electric wires and optical fibers, utilized in a high pressure, subsurface environment. The system utilizes signal transmission lines deployed in the interior of a tube, such as a stainless steel tube, extending to a subsurface location, such as a downhole location within a wellbore.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will hereafter be described with reference to the accompanying drawings, wherein like reference numerals denote like elements, and:

Figure 1 is a front elevational view of a system, according to a preferred embodiment of the present invention, utilized in a downhole, wellbore environment;

Figure 2 is an elevational view similar to Figure 1 but showing a pump to pressurize the system;

Figure 3 is a cross-sectional view of an exemplary combination of a signal transmission line extending through the interior of a protective tube, according to a preferred embodiment of the present invention;

Figure 4 is a cross-sectional view similar to Figure 3 illustrating an alternate embodiment;

Figure 5 is a cross-sectional view similar to Figure 3 illustrating another alternate embodiment;

Figure 6 is a cross-sectional view taken generally along the axis of an exemplary protective tube, illustrating another alternate embodiment;

Figure 6A is a radial cross-sectional view illustrating another alternate embodiment;

Figure 6B is a cross-sectional view similar to Figure 6A but showing a different transmission line;

Figure 7 is an axial cross-sectional view of an exemplary connector utilized in connecting a protective tubing to a downhole tool;

Figure 8 is a cross-sectional view taken generally along the axis of a penetrator having a hydraulic bypass; and

Figure 9 is an alternate embodiment of the penetrator illustrated in Figure 8.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring generally to Figure 1, a system 10 is illustrated according to a preferred embodiment of the present invention. One exemplary environment in which system 10 is utilized is a well 12 within a geological formation 14 containing desirable production fluids, such as petroleum. In the application illustrated, a wellbore 16 is drilled and lined with a wellbore casing 18.

In many systems, the production fluid is produced through a tubing 20, e.g. production tubing, by, for example, a pump (not shown) or natural well pressure. The production fluid is forced upwardly to a wellhead 22 that may be positioned proximate the surface of the earth 24. Depending on the specific production location, the wellhead 22 may be land-based or sea-based on an offshore production platform. From wellhead 22, the production fluid is directed to any of a variety of collection points, as known to those of ordinary skill in the art.

A variety of downhole tools are used in conjunction with the production of a given wellbore fluid. In Figure 1, a tool 26 is illustrated as disposed at a specific downhole location 28. Downhole location 28 is often at the center of very hostile conditions that may include high temperatures, high pressures (e.g., 15,000 PSI) and deleterious fluids. Accordingly, overall system 10 and tool 26 must be designed to operate under such conditions.

For example, tool 26 may constitute a pressure temperature gauge that outputs signals indicative of downhole conditions that are important to the production operation; tool 26 also may be a flow meter that outputs a signal indicative of flow conditions; and tool 26 may be a flow control valve that receives signals from surface 24 to control produced fluid flow. Many other types of tools 26

also may be utilized in such high temperature and high pressure conditions for either controlling the operation of or outputting data related to the operation of, for example, well 12.

The transmission of a signal to or from tool 26 is carried by a signal transmission line 30 that extends, for example, upward along tubing 20 from tool 26 to a controller or meter system 32 disposed proximate the earth's surface 24. Exemplary signal transmission lines 30 include electrical cable that may include one or more electric wires for carrying an electric signal or an optic fiber for carrying optical signals. Signal transmission line 30 also may comprise a mixture of signal carriers, such as a mixture of electric conductors and optical fibers.

The signal transmission line 30 is surrounded by a protective tube 34. Tube 34 also extends upwardly through wellbore 16 and includes an interior 36 through which signal transmission line 30 extends. A fluid communication path 37 also extends along interior 36 to permit the flow of fluid therethrough.

Typically, protective tube 34 is a rigid tube, such as a stainless steel tube, that protects signal transmission 30 from the subsurface environment. The size and cross-sectional configuration of the tube can vary according to

application. However, an exemplary tube has a generally circular cross-section and an outside diameter of one quarter inch or greater. It should be noted that tube 34 may be made out of other rigid, semi-rigid or even flexible materials in a variety of cross-sectional configurations. Also, protective tube 34 may include or may be connected to a variety of bypasses that allow the tube to be routed through tools, such as packers, disposed above the tool actually communicating via signal transmission line 30.

Protective tube 34 is connected to tool 26 by a connector 38. Connector 38 is designed to prevent leakage of the high pressure wellbore fluids into protective tube 34 and/or tool 26, where such fluids can detrimentally affect transmission of signals along signal transmission line 30. However, most connectors are susceptible to deterioration and eventual leakage.

To prevent the inflow of wellbore fluids, even in the event of leakage at connector 38, fluid communication path 37 and connector 38 are filled with a fluid 40. An exemplary fluid 40 is a liquid, e.g., a dielectric liquid used with electric lines to help avoid disruption of the transmission of electric signals along transmission line 30.

Fluid 40 is pressurized by, for example, a pump 42 that may be a standard low pressure pump coupled to a fluid

supply tank. Pump 42 may be located proximate the earth's surface 24, as illustrated, but it also can be placed in a variety of other locations where it is able to maintain fluid 40 under a pressure greater than the pressure external to connector 38 and protective tube 34. Due to its propensity to leak, it is desirable to at least maintain the pressure of fluid within connector 38 higher than the external pressure at that downhole location. However, if pump 42 is located at surface 24, the internal pressure at any given location within protective tube 34 and connector 38 typically is maintained at a higher level than the outside pressure at that location. Alternatively, the pressure in tube 34 may be provided by a high density fluid disposed within the interior of the tube.

In the event connector 38 or even tube 34 begins to leak, the higher internal pressure causes fluid 40 to flow outwardly into wellbore 16, rather than allowing wellbore fluids to flow inwardly into connector 38 and/or tube 34. Furthermore, if a leak occurs, pump 42 preferably continues to supply fluid 40 to connector 38 via protective tube 34, thereby maintaining the outflow of fluid and the protection of signal transmission line 30. This allows the continued operation of tool 26 where otherwise the operation would have been impaired.

In fact, pump 42 and fluid communication path 37 can be utilized for hydraulic control. The ability to move a liquid through tube 34 may also allow for control of certain hydraulically actuated tools coupled to tube 34.

Referring generally to Figures 3 through 5, a variety of exemplary transmission lines 30 are shown disposed within protective tube 34. In Figure 3, signal transmission line 30 includes a single electric wire or optic fiber 44. The single wire or optic fiber 44 is surrounded by an insulative layer 46 that may comprise a plastic material, such as non-elastomeric plastic. Fluid 40 surrounds the signal transmission line 30 within the interior 36 of tube 34.

In Figure 4, the wire or optic fiber 44 is surrounded by a thicker insulation layer 48, such as an elastomeric layer. The radial thickness of insulation 48 is selected according to the specific gravity or density of fluid 40 to provide a support for signal transmission line 30. For example, if fluid 40 is a dielectric liquid, insulation layer 48 is selected such that signal transmission line 30 is supported within fluid 40 by its buoyancy. Preferably, the average density of insulation layer 48 and wire or fiber 44 is selected such that the signal transmission line 30 floats neutrally within fluid 40. In other words, there is minimal tension in line 30, because it is not affected by a greater density relative to the liquid (resulting in a

downward pull) or a lesser density (resulting in an upward pull).

In the alternate embodiment illustrated in Figure 5, a plurality of wires, optic fibers, or a mixture thereof, is illustrated as forming signal transmission line 30. Each wire or fiber 50 is surrounded by a relatively thin insulation layer 52 and connected to a float 54. Float 54 preferably is designed to provide signal transmission line 30 with neutral buoyancy when disposed in fluid 40, e.g. a dielectric liquid.

Other embodiments for supporting signal transmission line 30 within tube 34 are illustrated in Figures 6 and 6A. As illustrated in Figure 6, for example, line 30 may be supported by contact with the interior surface of tube 34. With this type of physical support, it may be desirable to wrap any conductive wires or optical fibers in an outer wrap 56 that has sufficient stiffness to permit frictional contact between outer wrap 56 and the interior surface of tube 34 at multiple locations along tube 34.

In another embodiment, illustrated in Figures 6A and 6B, signal transmission line 30 is supported by a support member 57. Member 57 extends between the inner surface of tube 34 and signal transmission line 30 to provide support. An exemplary support member 57 includes a hub 58 disposed in

contact with line 30 and a plurality of wings 59, e.g. four wings, that extend outwardly to tube 34. Wings 59 permit uninterrupted flow of fluid along fluid communication path 37.

In an exemplary application, tube 34 is drawn over support member 57 to provide an interference fit. Preferably, an interference fit is provided between signal transmission line 30 and hub 58 as well as between the radially outer ends of wings 59 and the inner surface of tube 34. It also should be noted that if tube 34 is formed of a polymer rather than a metal, the polymer tube can be extruded on the winged profile of support member 57.

Additionally, the winged support members can be used to draw a second tube, such as a stainless steel tube, over an inner steel tube, such as tube 34 or other types of tubes able to carry signal and/or power transmission lines. Effectively, any number of concentric tubes, e.g. steel or polymer tubes, with varying internal diameters, can be supported by each other via concentrically deployed support member 57.

Wings 59 may have a variety of shapes, including hourglass, triangular, rectangular, square, trapezoidal, etc., depending on application and design parameters. Also, the number of wings utilized can vary depending on the

configuration of the signal and/or power transmission lines. Exemplary materials for support member 57 include thermoplastic, elastomer or thermoplastic elastomeric materials. Many of these materials permit the winged profile of support member 57 to be extruded onto the signal and/or power transmission lines by a single extrusion. Additionally, separate winged members can be formed, and communication between the independent wings can be accomplished by cutting slots into the wings at regular intervals. One advantage of utilizing support member or members 57 (or the frictional engagement described with respect to Figure 6) is that these embodiments do not require selection of fluids 40 or float materials that create neutral or near neutral buoyancy of line 30 within fluid 40.

Referring generally to Figure 7, an exemplary connector 38 is illustrated. Connector 38 includes a tool connection portion 60 designed for connection to tool 26. The specific design of tool connection portion 60 varies according to the type or style of tool to which it is connected. Typically, the signal transfer line 30 is electrically, optically or otherwise connected to tool 26 by an appropriate signal transmission line connector 62. Connector 38 also includes a connection chamber 64 that may be pressurized with fluid 40 to ensure an outflow of fluid 40 in the event a leak occurs around connector 38. Connection chamber 64 may be

separated from tool connection portion 60, at least in part, by an internal wall 66.

Tube 34, and particularly interior 36 of tube 34, extends into fluid communication with connection chamber 64 via an opening 68 formed through a connector wall 70 that defines chamber 64. With this configuration, signal transmission line 30 extends through interior 36 and connection chamber 64 to an appropriate signal transmission line connector 62 coupled to tool 26. The actual sealing of tube 34 to connector 38 may be accomplished in a variety of ways, including welding, threaded engagement, or the use of a metal seal, such as by compressing a stainless steel ferrule over the connecting end of tube 34, as done in conventional systems and as known to those of ordinary skill in the art. Regardless of the method of attachment, fluid 40 is directed through interior 36 to connection chamber 64 and maintained at a pressure (P2) that is greater than the external or environmental pressure (P1) acting on the exterior of connector 38 and tube 34 at a given location.

In certain applications, it is desirable to ensure against backflow of wellbore fluids through tube 34, at least across certain zones. For example, tube 34 may extend across devices, such as a tubing hanger disposed at the top of a completion, an annulus safety valve, and a variety of packers disposed in wellbore 16 at a location dividing the

wellbore into separate zones above and below the packer. If tube 34 is broken or damaged, it may be undesirable to allow wellbore fluid to flow from a lower zone to an upper zone across one or more of these exemplary devices. Accordingly, it is desirable to utilize a barrier, sometimes referred to as a penetrator, to prevent fluid flow across zones. Existing penetrators, however, do not allow fluid circulation, so they cannot be used with a pressurized connector system of the type described herein.

As illustrated in Figure 8, an improved penetrator 74 is illustrated as deployed in a zone separation device 76, such as a packer (e.g. a feed-through packer), a tubing hanger or an annulus safety valve. Device 76 separates the wellbore into an upper annulus region 78 and a lower annulus region 80.

Tube 34 is separated into an upper portion 34A and a lower portion 34B. Upper portion 34A extends downwardly into a sealed upper cavity 82 of penetrator 74, while lower tube section 34B extends upwardly into a sealed lower cavity 84 of penetrator 74. Sealed upper cavity 82 is connected to sealed lower cavity 84 by a fluid bypass 86 that includes a one way check valve 88. Check valve 88 permits the flow of fluid 40 downwardly through penetrator 74, but it prevents the backflow of fluid in an upward direction through penetrator 74. Thus, if lower tube 34B is broken or

damaged, any backflow of wellbore fluid is terminated at check valve 88.

The signal transmission line 30 passes through a solid wall 90 separating sealed upper cavity 82 from sealed lower cavity 84. Preferably, line 30 has an upper connection 92 and a lower connection 94 that are coupled together via one or more high pressure feed-throughs 96 that extend through wall 90. It should be noted that the signal transmission line 30 can be connected to a tool at and/or below penetrator 74 to provide communication and/or power to the tool. Also, fluid 40, e.g. a liquid, can be utilized not only in the actuation of tools below zone separation device 76 but also device 76 itself. For example, if device 76 comprises a hydraulically actuated packer, the fluid 40 can be selected and used for hydraulic actuation.

An alternate embodiment of penetrator 74 is illustrated in Figure 9 and labeled as penetrator 74A. In this implementation, penetrator 74A is designed as an independent sub to be secured, for example, to the lower face of or inside device 76, such as to the lower face or inside of a packer body.

In the embodiment illustrated, the packer body includes a threaded bore 98 for receiving a threaded top end 100 of penetrator 74A. A metal-to-metal seal 102 is formed between

a chamfered penetrator edge 104 and a chamfered surface 106 disposed on the body of device 76. Additionally, the upper tube 34A is sealed to the body of device 76 by any of a variety of conventional methods known to those of ordinary skill in the art. Lower tube 34A, however, is sealed to a tubing or cable head 108 which, in turn, is sealably coupled to penetrator 74A. For example, tube head 108 may include a threaded region 110 designed for threaded engagement with a threaded lower end 112 of penetrator 74A. A seal 114 may be formed between tube head 108 and penetrator 74A when threaded regions 110 and 112 are securely engaged. Signal transmission line 30 includes an upper connector 116 and a lower connector 118 that are coupled across an electric feed-through 120 that is threadably engaged with penetrator 74A, as illustrated.

The penetrator 74A further includes a hydraulic bypass 122 that includes a check valve 124, such as a one-way ball valve. Thus, fluid 40 may flow from tube 34A downwardly through fluid bypass 122 and into lower tube 34B. However, if lower tube 34B is ruptured or damaged, any wellbore fluid flowing upwardly through lower tube 34B is prevented from flowing past device 76 by check valve 124. Accordingly, no wellbore fluids flow from a lower zone beneath the device 76 to an upper wellbore zone above device 76.

It will be understood that the foregoing description is of preferred exemplary embodiments of this invention, and that the invention is not limited to the specific forms shown. For example, the pressurized fluid system may be used in a variety of subsurface environments, either land-based or sea-based; the system may be utilized in wellbores for the production of desired fluids or in a variety of other high pressure and/or high temperature environments; and the specific configuration of the tubing, pressurized fluid, tool, signal transmission line, and penetrator may be adjusted according to a specific application or desired design parameters. These and other modifications may be made in the design and arrangement of the elements without departing from the scope of the invention as expressed in the appended claims.

CLAIMS

1. A system of transferring a signal for a device disposed at a subsurface location, comprising:

a tool disposed at a subsurface location;

a tube extending to the tool, the tube having an interior with a fluid communication path;

a signal transmission line coupled to the tool and disposed in the interior; and

a fluid disposed along the fluid communication path, wherein at any location along the tube the fluid is maintained at a pressure higher than the external pressure acting on the tube at that location.

2. The system as recited in claim 1, wherein the fluid comprises a liquid.

3. The system as recited in claim 2, wherein the liquid comprises a dielectric liquid.

4. The system as recited in claim 1, wherein the tube has a generally circular cross-section.

5. The system as recited in claim 1, wherein the tool comprises a sensor.

6. The system as recited in claim 1, wherein the tool comprises a valve.

7. The system as recited in claim 1, wherein the signal transmission line comprises an optical fiber.

8. The system as recited in claim 1, wherein the signal transmission comprises at least one conductive wire.

9. The system as recited in claim 1, further comprising a connector disposed to connect the tube to the tool.

10. The system as recited in claim 1, wherein the subsurface location is a downhole wellbore location.

11. The system as recited in claim 1, further comprising a support able to support the signal transmission line within the interior of the tube.

12. The system as recited in claim 11, wherein the support comprises a float.

13. The system as recited in claim 11, wherein the support comprises a winged member.

14. The system as recited in claim 1, further comprising a pump disposed at the earth's surface to maintain the fluid under pressure.

15. A method for promoting the useful life of a subsurface tool, comprising:

connecting a signal transfer line to a tool;

surrounding at least a portion of the signal transfer line with an enclosure; and

pressurizing the enclosure such that the internal pressure is greater than the external pressure.

16. The method as recited in claim 15, further comprising connecting the enclosure to the tool.

17. The method as recited in claim 16, further comprising forming the enclosure with a connector attached to the tool and a tube attached to the connector.

18. The method as recited in claim 17, further comprising placing a liquid within the tube and the connector.

19. The method as recited in claim 15, further comprising transmitting an optical signal over the signal transfer line.

20. The method as recited in claim 15, further comprising transmitting an electrical signal over the signal transfer line.

21. The method as recited in claim 15, further comprising deploying the tool within a wellbore at a downhole location.

22. The method as recited in claim 18, further comprising preventing a back flow of the dielectric fluid along the tube.

23. The method as recited in claim 22, wherein deploying includes deploying a flow control valve.

24. The method as recited in claim 22, wherein deploying includes deploying a sensor.

25. The method as recited in claim 22, further comprising pumping additional dielectric liquid into the tube to compensate for a leak.

26. The method as recited in claim 18, further comprising adding a float to the signal transfer line.

27. The method as recited in claim 18, further comprising utilizing the liquid for a hydraulic actuation.

28. The method as recited in claim 17, further comprising supporting the signal transfer line by a member disposed in an interference fit between the signal transfer line and the tube.

29. The method as recited in claim 28, wherein supporting includes deploying a plurality of wings between the signal transfer line and the tube.

30. A system for improving the useful life of a tool utilized at a downhole location in a wellbore, comprising:

a connector configured for connection to a tool, the connector having a connection chamber that may be pressurized with a fluid at a pressure higher than the external pressure of the wellbore; and

a tube having an interior with a fluid communication path disposed in fluid communication with the connection chamber.

31. The system as recited in claim 30, further comprising a tool attached to the connector.

32. The system as recited in claim 31, further comprising a signal transfer line extending along the interior and the connection chamber for communication with the tool.

33. The system as recited in claim 32, further comprising a high pressure feed-through having a check valve.

34. The system as recited in claim 32, further comprising a liquid disposed along the fluid communication path and the connection chamber, wherein the liquid is pressurized such that the liquid pressure in the connection chamber is greater than the pressure on the exterior of the connector.

35. The system as recited in claim 34, wherein the signal transfer line comprises an optical fiber.

36. The system as recited in claim 34, wherein the signal transfer line comprises an electrical cable.

37. The system as recited in claim 34, wherein the liquid comprises a dielectric liquid.

38. The system as recited in claim 37, wherein the signal transfer line has an average density selected to permit the signal transfer line to float in the liquid.

39. The system as recited in claim 38, wherein the signal transfer line includes a plastic outer layer.

40. A connector system, comprising:

a connector having an internal connection chamber;

a signal transmission line disposed through the internal connection chamber; and

a fluid disposed in the internal connection chamber at a pressure higher than the external pressure acting on the connector.

41. The connector system as recited in claim 40, wherein the fluid comprises a liquid.

42. The connector system as recited in claim 41, wherein the signal transmission line comprises an optical line.

43. The connector system as recited in claim 41, wherein the signal transmission line comprises an electrically conductive line.

44. The connector system as recited in claim 41, further comprising a tube coupled to the connector for communication with the internal connection chamber.

45. The connector system as recited in claim 44, wherein the tube supplies additional liquid to the internal connection chamber in the event the liquid leaks from the internal connection chamber.

46. The connector system as recited in claim 45, further comprising a tool attached to the connector.

47. A method for forming a connection between a tube and a tool in a high pressure environment, comprising:

forming a connector with a rigid outer wall and an internal chamber;

attaching the connector to a tool at a first end and to a tube at a second end;

filling the internal chamber with a fluid; and

sufficiently pressurizing the fluid to provide an outflow of the fluid in the event a leak occurs proximate the connector.

48. The method as recited in claim 47, further comprising supplying the internal chamber with the fluid via the tube.

49. The method as recited in claim 48, wherein filling comprises filling the internal chamber with a liquid.

50. The method as recited in claim 49, further comprising deploying a signal transmission line through the internal chamber.

51. The method as recited in claim 50, further comprising sending an optical signal along the signal transmission line.

52. The method as recited in claim 50, further comprising sending an electrical signal along the signal transmission line.

53. The method as recited in claim 49, further comprising locating the connector at a subsurface location.

54. The method as recited in claim 49, further comprising locating the connector at a downhole location within a wellbore.

55. A system for preventing a backflow of wellbore fluids from a downhole zone within a wellbore lined with a wellbore casing, comprising:

a penetrator system comprising a flow-through passage having a one-way check valve;

an upper fluid tube disposed in fluid communication with the flow-through passage upstream of the one-way check valve; and

a lower fluid tube disposed in fluid communication with the flow-through passage downstream of the one-way check valve.

56. The system as recited in claim 55, further comprising:

a production tubing; and

a zone separation device disposed between the production tubing and the wellbore casing.

57. The system as recited in claim 56, wherein the zone separation device comprises a feed-through packer.

58. The system as recited in claim 56, wherein the zone separation device comprises a tubing hanger.

59. The system as recited in claim 56, wherein the zone separation device comprises an annulus safety valve.

60. The system as recited in claim 56, wherein the penetrator system is connected with the zone separation device.

61. The system as recited in claim 55, further comprising an upper signal transmission line disposed within the upper fluid tube.

62. The system as recited in claim 61, further comprising a lower signal transmission line disposed within the lower fluid tube.

63. The system as recited in claim 62, wherein the upper signal transmission line and the lower signal

transmission line are coupled to each other at the penetrator system.

64. The system as recited in claim 62, wherein the upper and lower signal transmission lines each comprise an electrical conductor.

65. The system as recited in claim 62, wherein the upper and lower signal transmission lines each comprise an optical fiber.

66. The system as recited in claim 62, wherein the upper and lower signal transmission lines each comprise an electrical conductor and an optical fiber.

67. The system as recited in claim 55, further comprising a liquid disposed in the upper fluid tube, the lower fluid tube and the flow-through passage.

68. The system as recited in claim 67, wherein the liquid comprises a dielectric liquid.

69. The system as recited in claim 67, wherein the liquid is utilized to actuate a downhole tool.

70. The system as recited in claim 60, further comprising a liquid disposed in the upper fluid tube,

wherein the liquid is utilized to actuate the zone separation device.

71. The system as recited in claim 55, further comprising a signal transmission line disposed in at least the upper fluid tube; and a tool coupled to the signal transmission line for communication therethrough.

72. The system as recited in claim 60, further comprising a signal transmission line disposed in at least the upper fluid tube, wherein the signal transmission line is coupled to the zone separation device for communication therewith.

73. A system for use in a wellbore to permit the simultaneous production of wellbore fluids and communication with a downhole device, comprising:

a device having a production opening through which a wellbore fluid may be produced; a flow-through passage independent of the production opening, wherein the flow-through passage includes a one-way check valve to permit fluid flow in a direction opposite the flow of a production fluid produced through the production opening; and

a signal transmission line feed-through.

74. The system as recited in claim 73, further comprising a production tubing disposed through the production opening for carrying a produced fluid.

75. The system as recited in claim 73, wherein the device comprises a feed-through packer.

76. The system as recited in claim 73, further comprising a tube deployed in fluid communication with the flow-through passage on both sides of the one-way check valve.

77. The system as recited in claim 73, further comprising a signal transmission line disposed within the tube, wherein the signal transmission line is routed around the one-way check valve through the signal transmission line feed-through.

78. The system as recited in claim 77, wherein the signal transmission line comprises an electrical conductor.

79. The system as recited in claim 77, wherein the signal transmission line comprises an optical fiber.

80. A system for preventing a backflow of fluid in a pressurized tube used to prolong the communication of signals with a tool, comprising:

a tube having an internal fluid communication path;

a signal transmission line disposed within the tube; and

a backflow prevention device disposed at a desired location along the tube, the backflow prevention device including a one-way bypass to permit the flow of fluid therethrough as the fluid moves along the internal fluid communication path, and a feed-through through which the signal transmission line extends.

81. The system as recited in claim 80, wherein the one-way bypass includes a check valve.

82. The system as recited in claim 81, wherein the signal transmission line comprises an optical fiber.

83. The system as recited in claim 81, wherein the signal transmission line comprises an electrical conductor.

84. The system as recited in claim 80, further comprising a liquid disposed in the tube and the one-way

bypass, wherein the liquid is under greater pressure than the external pressure acting on the tube.

85. The system as recited in claim 84, wherein the backflow prevention device is disposed in a wellbore to prevent the backflow of a wellbore fluid.

86. The system as recited in claim 85, wherein the backflow prevention device is deployed in a packer.

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Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): E1F : FAC, FHK

Int Cl (Ed.7): E21B

Other: Online: EPODOC, JAPIO, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	US 6060662 A	(WESTERN ATLAS)	-
X	US 5769160 A	(PES INC.)	1 to 11, 14 -25, 27, 28

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